2P4-2

Impregnation of mesh with liquid droplet containing abrasive grains by sound waves from a sound source with a circular transverse vibrating plate

円形たわみ振動板型音源から放射された音波による
砥粒を混ぜた液滴の含浸

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1. Introduction

Metal meshes are impregnated with liquid in a wide range of applications such as in coating conveyor belt mesh with fluorine[1]. Irradiation with powerful aerial ultrasonic waves is a non-contact method that can improve the wettability of meshes for liquid[2], and we have been developing a non-contact method for impregnating materials with liquid by using aerial ultrasonic waves. In this work, we investigated impregnating a mesh with liquid droplets of various volumes containing abrasive grains by converging sound waves with a sound waveguide to increase the sound pressure.

2. Ultrasonic sound source and sound waveguide

Figure 1 shows a schematic of the aerial ultrasonic sound source. A duralumin exponential horn (thick end face diameter: 40 mm; narrow end face diameter: 8 mm; length: 89 mm; amplitude expansion ratio: 5.0) is attached to a 28 kHz duralumin bolted Langevin transducer and resonance rod (diameter: 8 mm; length: 70 mm) for propagating longitudinal vibration. A duralumin circular transducer vibrating plate (diameter: 106 mm; thickness: 1 mm, manufactured by Duralumin) is joined to the tip with a screw. The resonance frequency of the nodal circle mode of the sound source is 27.6 kHz.

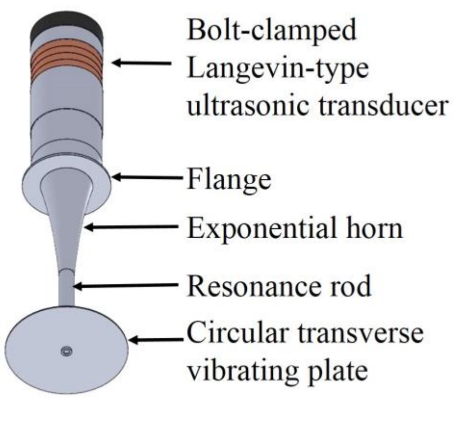

Fig. 1. Schematic of an ultrasonic source.

Figure 2 shows a side-on schematic of the apparatus. The sound waveguide is a 10 mm thick acrylic plate with a hole 4 mm in diameter, and is placed 24 mm below the vibrating plate. The mesh is attached to the lower surface of the sound waveguide with a tape.

3. Sound pressure characteristics with sound waveguide attached

The sound pressure near the mesh surface was measured with and without the sound waveguide attached (**Fig. 3**). The metal mesh was SUS 316 (plain weave; wire diameter: 0.06 mm; spacing: 0.109 mm). A 1/8 in.

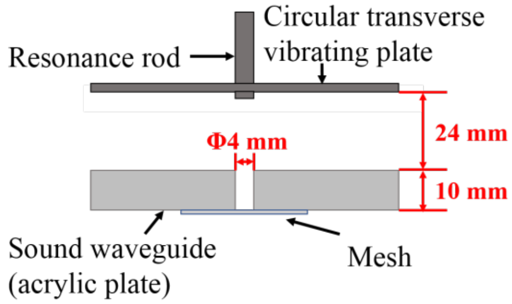

Fig. 2. Position of the ultrasonic source and sound wave guide.

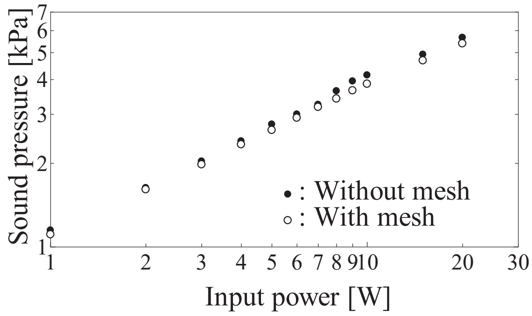

Fig. 3. Relationship between input power and sound pressure.

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microphone was set perpendicular to the guide on the fixed surface with the mesh attached to the lower part of the sound waveguide. In the figure, the vertical axis is sound pressure and the horizontal axis is input power.

The sound pressure obtained at an input power of 20 W was 5.4 kPa with the mesh and 5.6 kPa without the mesh; thus, the sound pressure did not depend on the presence of the mesh. The sound pressure was proportional to about half of the input power.

4. Impregnation of the mesh with liquid droplets containing abrasive grains

We investigated the impregnation by aerial ultrasonic irradiation of the mesh with a droplet of glycerin (viscosity: 1.412 Pa・s; volume: 10, 20, 30, or 40 μL) containing abrasive grains (white morundum: particle size: #120 or #1500) in a glycerin:abrasive ratio of 5:1 (w/w). We observed the liquid droplet before and after ultrasonic irradiation. The liquid droplet was placed on the mesh in the sound waveguide and irradiated with ultrasonic waves at an input power of 20 W.

Figures 4 to **7** show optical microscope images of the liquid droplet after ultrasonic irradiation from the back of the mesh at 30× (Figures 4(a)-7(a)) and 200× (Figures 4(b)-7(b)) magnification. Figures 4 and 5 show photographs of the droplet containing #120 abrasive grains. The droplet spread to the center and the impregnated area was larger than the guide hole (Figures 4(a) and 5(a)). The liquid droplet and abrasive grains impregnated the back of the mesh (Figures 4(b) and 5(b)). Figures 6 and 7 show photographs of the droplet containing #1500 abrasive grains. The liquid droplet and abrasive grains impregnated the back of the mesh. The liquid droplet appeared pale because of the abrasive grains. Other studies have found that a 10 μL liquid droplet impregnated a mesh at an input power of 30 W.

5. Conclusions

We investigated the non-contact impregnation of a mesh with liquid droplets using a circular transverse vibrating plate sound source and sound waveguide. At an input power of 20 W, liquid droplets with a volume of 20 μL or more impregnated the back of the mesh. It is also found that the impregnated area is larager than the guide hole at the amount of liquid increased.

Acknowledgment

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References

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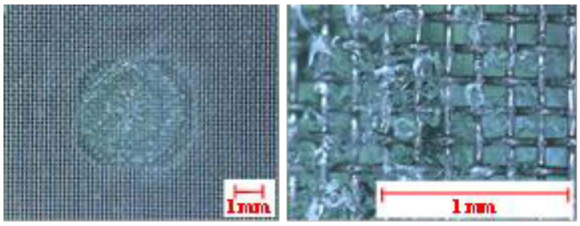
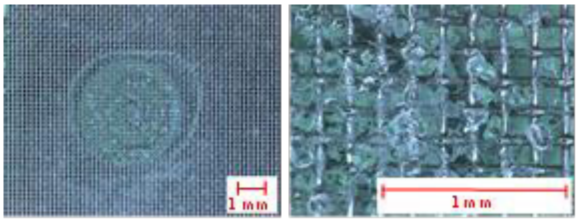


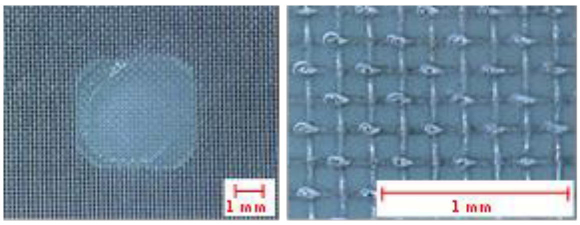
(a) 30× magnification (b) 200× magnification

Fig. 4. Microscope images of impregnation of mesh with liquid droplet (#120, 20 μL).



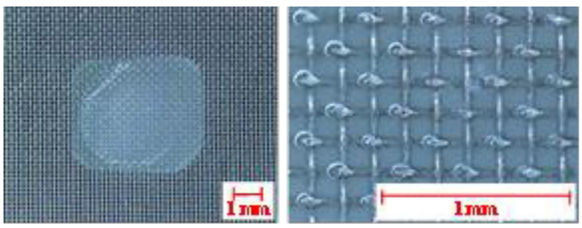
(a) 30× magnification (b) 200× magnification

Fig. 5. Microscope images of impregnation of mesh with liquid droplet (#120, 30 μL).



(a) 30× magnification (b) 200× magnification

Fig. 6. Microscope images of impregnation of mesh with liquid droplet (#1500, 20 μL).



(a) 30× magnification (b) 200× magnification

Fig. 7. Microscope images of impregnation of mesh with liquid droplet (#1500, 30 μL).